

DESCRIPTION OF FIGURES

Schizophoria peculiaris n. sp.

Figs. 1-4. Different views of one of three cotypes. Fig. 3 is of the natural size; the others are enlarged to about 3 diameters. Hueco limestone; Marble Canyon, east face of Diablo Plateau, Hudspeth County, Texas, (Station 6681).

Pustula palmeri n. sp.

Figs. 5-10. Different views of 3 cotypes, figs. 5-8 representing one specimen, fig. 9 another, and fig. 10 a third. Fig. 7 is of the natural size; the others are enlarged to about 3 diameters. Cherokee shale; mine dumps near Joplin, Mo.

Pustula keytei n. sp.

Figs. 11-14. Different views of two cotypes, all $\times 3$. Figs. 11-13 represent one specimen, fig. 14 another. Glen Eyrie shale member of the Fountain formation; Glen Eyrie, El Paso County, Colorado.

Avonia williamsana n. sp.

Figs. 15-19. Different views of 3 out of 7 cotypes. Figs. 15-17 represent one specimen, fig. 15 being an enlargement to two diameters. Fig. 18 represents an external mold of a brachial valve $\times 2$. Some of the holes made by the small spines are here shown. Fig. 19 represents a pedicle valve, $\times 2$. This specimen like the original of fig. 15 is practically an internal mold. Cherty beds of the Boone limestone; Joplin, Mo., (Station 1301A).

ZOOLOGY.—*The copepod genera Broteas Lovén, Paradiaptomus Sars, Lovenula Schmeil, Metadiaptomus Methuen, and Adiaptomus Cooper.*¹ C. DWIGHT MARSH, Bureau of Animal Industry.

In connection with a study of *Diaptomus* it became necessary to determine somewhat clearly what species should be separated from *Diaptomus* and referred to the proposed genera *Broteas*, *Paradiaptomus*, *Lovenula*, *Metadiaptomus*, and *Adiaptomus*. It was found difficult to get from the authors who have used these names any method of determining by a few characters the generic limits of these proposed divisions of the Diaptomidae. Gurney, 1929, discussed the matter somewhat elaborately, but did not make clear a practical method of separating the genera. This led the writer to go over the literature to see if he could find out how the authors used these names and whether it might be possible, in some fairly simple way, to make diagnoses of the genera. This was necessarily nothing but a study of the literature, as no material of these forms was available for examination. Such a critical study is always difficult because many published descriptions are incomplete and there is always a possibility, especially in the examination of minute structures, that there may be mistakes of observation, in making sketches, or of interpretation. When there is a discrepancy between authors, it may be assumed that the later author is right, although, of course, this would not always be true.

In 1847 Lovén proposed the generic name *Broteas* for a South African copepod giving a somewhat elaborate description with figures. This

¹ Received August 3, 1931.

differed from the recognized characteristics of *Diaptomus* in that the female abdomen was composed of two segments instead of three, the maxillipeds were long and powerful instead of rather weak and inconspicuous, the endopodites of the swimming feet were all two-segmented, while in *Diaptomus* the endopodites of the first feet are two-segmented and of the second, third, and fourth three-segmented, and the first antennae contained 27 segments instead of 25. The exopodite of the left 5th foot of the male was armed with a conspicuous hook, apparently terminal, and an acute spine.

In 1895 Sars described *Paradiaptomus lamellatus*, proposing the new genus *Paradiaptomus*. This, like *Broteas*, has two-segmented female abdomen and long and powerful maxillipeds; the endopodite of the maxilliped consisted of three segments instead of five as in *Diaptomus*. The swimming feet were like *Diaptomus*,—first foot two-segmented and the others of three segments. The exopodite of the left 5th foot of the male was armed with three spines.

In Giesbrecht and Schmeil, 1899, Schmeil proposed *Lovenula* in place of *Broteas*, since *Broteas* was preoccupied. His description was practically like that of Lovén, but he added that the endopodite of the maxilliped consisted of three segments. Thus the main distinction between *Lovenula* Schmeil, or *Broteas* Lovén, and *Paradiaptomus* Sars was that the endopodites of the swimming feet of *Lovenula* have *two segments*, while those in *Paradiaptomus* Sars are like those in *Diaptomus*, two-segmented in the first, and three-segmented in the others. Giesbrecht and Schmeil, 1898, diagnosed *Paradiaptomus* in accordance with the description of Sars as having the two-segmented female abdomen and three-segmented endopodite of the maxilliped as in *Lovenula* and the segmentation of the endopodites of the swimming feet as in *Diaptomus*.

Sars in 1899, from some collections in which he recognized, as he thought, the original species of Lovén, published a detailed description under the title "On the Genus *Broteas* of Lovén with Description of the Type Species: *Broteas falcifer* Lovén:" this description was accompanied with rather elaborate illustrations. He stated that Lovén was doubtless in error in the number of antennal segments which are 25 instead of 27. The last segment of the right antenna bears a small hook. The swimming feet, instead of having two-segmented endopodites, are like those in *Diaptomus*. He considered that these facts make *Broteas* identical with his *Paradiaptomus* and, as *Paradiaptomus* is the more recent name, he made it a synonym of *Broteas*.

Van Douwe, 1912, made some criticisms of preceding descriptions, but stated nothing that adds to our knowledge of the generic distinctions.

Gurney, 1904, in his description of "*Lovenula mea*" which is now considered identical with *Paradiaptomus falcifer* stated that the endopodites of the maxillipeds were *four-segmented*.

Brady, 1913, considered that *Paradiaptomus* should be used to include *Broteas* and *Lovenula*.

Grochmalicki, 1913, made *Paradiaptomus* Sars a synonym of *Lovenula* Schmeil, and listed 3 species of *Lovenula*, *L. falcifera* Loven, *L. lamellata* Sars, and *L. mea* Gurney. He added another species, *L. stolzmanni*.

Rühe, 1921, stated positively that the endopodite of the maxilliped of *Paradiaptomus* has *five* segments. Rühe claimed that Sars was in error in regard to the left fifth foot of the male; he stated that two spines are borne on the external margin of the second segment of the exopodite and a hyaline lamella on the internal margin; that there is a definite line separating the first and second segments which leave the spines on the second segment. Both Sars and Rühe make the left exopodite two-segmented, but they differ in the location of the division.

Sars, 1927, published descriptions of *Lovenula falcifera* and *L. barnardi*, and revived the genus name *Paradiaptomus* for *L. lamellatus*. In both *Lovenula* and *Paradiaptomus* he found the swimming feet like *Diaptomus*, the two-segmented female abdomen, and the endopodites of the maxillipeds *five-segmented*. He made *Paradiaptomus* somewhat different in form from *Lovenula*, the maxillipeds less powerfully developed, and no hook on the ultimate segment of the right male antenna.

Brehm, 1927, stated that the family Diaptomidae has only two genera, *Paradiaptomus* and *Diaptomus*, evidently discarding *Broteas* and *Lovenula*.

In 1906 Cooper proposed the name *Adiaptomus* for a species which he named *A. natalensis*. He stated that it has antennae of 26 segments, female abdomen of 2 segments, and his figure shows the male fifth foot of the same general form as that found in *Lovenula* Schmeil. The endopodites of the maxillipeds are three-segmented, and the swimming feet are like *Diaptomus*. There seems to be no reason for separating *Adiaptomus* from *Lovenula* except the 26-segmented antennae and possibly there was a mistake about this.

Metadiaptomus was proposed by Methuen in 1910 with the type species *M. transvallensis*. The antennae are of 26 segments, as stated

for *Adiaptomus*. The female abdomen is three-segmented. The swimming feet are like *Diaptomus*. In the male fifth feet, fig. 3, the second basal segment of the right foot is very much enlarged on the inner border, and this border and part of the dorsal surface is spinose. The left exopodite of the male fifth foot is one- or possibly two-segmented and bears two processes, a strong curved spine on the dorsal surface which, in the type species, is nearly as long as the whole exopodite, and a small terminal spine.

Gurney, 1929, recognized the two genera *Paradiaptomus* and *Metadiaptomus*, dividing *Paradiaptomus* into a *Paradiaptomus* and a *Lovenula* series.

The various ideas about the genera are summarized in Table 1. *Diaptomus* is added for comparison.

It appears that the original descriptions of *Broteas* and *Lovenula* made them differ from *Diaptomus* in the prominence of the maxillipeds, the segmentation of the swimming feet, the female abdomen, and the endopodite of the maxilliped. *Paradiaptomus* Sars 1895 differs from *Broteas* Lovén and *Lovenula* Schmeil in having the swimming feet like those of *Diaptomus*, and in the structure of the exopodite of the left 5th foot of the male. In regard to the segmentation of the endopodite of the maxilliped there has been a progressive change in authors' statements, the more recent making it five, like *Diaptomus*. If we assume, as one naturally would, that the later authors are more correct, it is probable that we should consider that this segmentation is five. It appears, however, that while the division of this endopodite in *Diaptomus* is clearly in five segments they are not so clearly marked in the other genera and hence have been sometimes overlooked. The maxilliped is highly developed and conspicuous in *Paradiaptomus*, *Lovenula*, and *Broteas*, and inconspicuous in *Diaptomus* and *Metadiaptomus*. There is a small hook on the ultimate segment of the right male antenna in *Broteas* and *Lovenula* of Sars and *Paradiaptomus* of Gurney.

The female abdomen in *Broteas*, *Paradiaptomus*, *Lovenula*, and *Adiaptomus* is 2-segmented, while in *Diaptomus* and *Metadiaptomus* it is 3-segmented. This is not a hard and fast distinction, however, for a few species of *Diaptomus* have 2-segmented abdomens. Sars writes of some *Diaptomi* in which the female abdomen has the last two segments "confluent." One might raise the question whether, in such cases, if they were "confluent," it might not be better to consider the abdomen to be two-segmented.

There are differences in the male fifth feet which help materially in distinguishing the genera. As shown in the copy of Sars' figure of the fifth feet of *Broteas falcifer* (Fig. 1), which now should be called *Lovenula*, the left exopodite has a well developed terminal hook and an acute spine. The left endopodite is either lacking or rudimentary.

TABLE 1. SUMMARY OF CHARACTERS

	Swimming feet	Female Abd.	Endop. Maxilliped	Ult. seg. male rt. ant.	Armature left endop. of male 5th ft.
<i>Broteas</i> Loven 1847	1-4, 2 seg.	2 seg.			Hook & acute spine.
<i>Paradiaptomus</i> Sars 1895	1, 2 seg. 2-4, 3 seg.	2 seg.	Prominent, Endop. 3 seg.		3 stout spines.
<i>Lovenula</i> Schmeil 1898	1-4, 2 seg.	2 seg.	Prominent, Endop. 3 seg.		Hook & acute spine.
<i>Paradiaptomus</i> 1898	1-2 seg. 2-4, 3 seg.	2 seg.	Prominent, Endop. 3 seg.		3 spines.
<i>Broteas</i> Sars 1899	2-4, 3 seg.	2 seg.	Prominent, Endop. 3 seg.	Ter. hook.	Hook & acute spine.
<i>Lovenula</i> Gurney 1904			Prominent, Endop. 4 seg.		Hook & acute spine.
<i>Paradiaptomus</i> Brady 1913		2 seg.			Hook & acute spine.
<i>Paradiaptomus</i> Ruhe 1921			Prominent, Endop. 5 seg.		2 spines & hyaline lam.
<i>Lovenula</i> Sars 1927	2-4, 3 seg.	2 seg.	Prominent, Endop. 4 seg.	Ter. hook	Hook & acute spine.
<i>Paradiaptomus</i> 1927	2-4, 3 seg.		Prominent, Endop. 4 seg.		3 spines.
<i>Paradiaptomus</i> , including <i>Lovenula</i> , Gurney 1929		2 seg.	Prominent, Endop. 5 seg.	Ter. hook	
<i>Adiaptomus</i> Cooper 1906	2-4, 3 seg.	2 seg.	Endop. 3 seg.		Hook & spine.
<i>Metadiaptomus</i> Methuen 1910	2-4, 3 seg.	3 seg.			Large curved spine on posterior surface. Small spine near end.
<i>Diaptomus</i>	2-4, 3 seg.	3 seg.	Not prominent Endop. 5 seg.		

Paradiaptomus Sars, as shown in his figure of *P. lamellatus* (Fig. 2) has a distinct left endopodite and the exopodite is armed either with three rather stout spines, as stated by Sars, or with two spines and a hyaline lamella according to Ruhe.

Adiaptomus has male fifth feet like *Lovenula*. *Metadiaptomus*, as shown in the figure from Methuen of *M. transvaalensis* (Fig. 3), has a stout curved spine on the posterior face of the exopodite and a smaller terminal spine. In addition, the second basal segment of the right foot is much enlarged on the inner side and the inner border and part of the posterior surface is armed with spinules.

The following suggestion then is made for distinguishing between these genera:

Lovenula Schmeil has 2-segmented female abdomen, prominent maxillipeds, the left exopodite of the male fifth foot armed with a terminal hook and an acute spine.

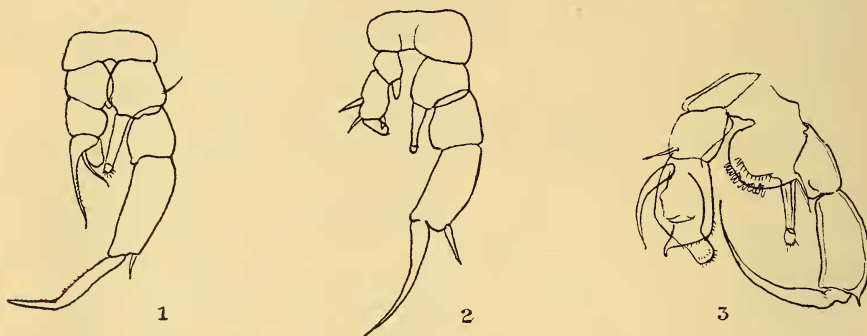


Fig. 1. Fifth foot of male of *Lovenula falcifera*. After Sars.

Fig. 2. Fifth foot of male of *Paradiaptomus lamellatus*. After Sars.

Fig. 3. Fifth foot of male of *Metadiaptomus transvaalensis*. After Methuen.

Paradiaptomus Sars has 2-segmented female abdomen, prominent maxillipeds, the left exopodite of the male fifth root armed with 2 stout spines and a hyaline lamella.

Metadiaptomus has 3-segmented female abdomen, maxillipeds not prominent, the left exopodite of the male fifth foot armed with a curved spine on the posterior surface and a small terminal spine. The second basipodite of the right male fifth foot is enlarged on the inner side and spinulose.

Adiaptomus is a synonym of *Lovenula*.

Lovenula will include *Broteas falcifer* Loven 1847, *Lovenula excellens* Kiefer 1921, *Adiaptomus natalensis* Cooper 1906, *Diaptomus bouvieri* Daday 1910, *Paradiaptomus biramata* Lowndes 1930, *P. biramata* Ruhe 1921, *P. biramata* Van Douwe 1912, *Broteas falcifer* Sars 1899,

Lovenula falcifera Sars 1927, *L. barnardi* Sars 1927, *Paradiaptomus falcifer* Brady 1913, *Lovenula* Giesbrecht & Schmeil 1898, *Broteas falcifer* Metheun 1910, *Lovenula mea* Gurney 1904, *Diaptomus africanus* Daday 1908, *D. aethiopicus* Daday 1908, *Lovenula simplex* Kiefer 1929, *Diaptomus pictus* Brady 1913 (which as suggested by Gurney 1929 is probably a synonym of Cooper's *Adiaptomus natalensis*), and possibly *Diaptomus alluaudi* DeGuerne & Richard 1890 (but female has 3-segmented abdomen).

Paradiaptomus will include *Paradiaptomus lamellatus* Sars 1895, *P. lamellatus* Ruhe 1921, *P. lamellatus* Giesbrecht & Schmeil 1898, *Broteas lamellatus* Sars 1899, *Paradiaptomus lamellatus* Sars 1927, and *Lovenula stolzmanni* Grochmalicki 1913.

Metadiaptomus will include *M. transvaalensis* Methuen 1910, *Paradiaptomus transvaalensis* Kiefer 1929, *Paradiaptomus colonialis* Kiefer 1928, *Diaptomus meridianus* Van Douwe 1912, *D. mascalus* Brady 1913, *D. capensis* Sars 1901, *D. purcelli* Sars 1901, *D. chevreuxi* De Guerne & Richard 1894, *D. alluaudi* De Guerne & Richard 1890, *D. rigidus* Sars 1927, Probably *D. asiaticus* Uljanin 1875, *D. rehmanni* Grock 1913, and *D. tibetanus* Daday 1908.

Diaptomus greeni Gurney 1907, called *Paradiaptomus greeni* Gurney 1931, and the two species described by Van Douwe 1912 as *Paradiaptomus schultzei* and *P. similis*, are considered as probably *Diaptomi*. Gurney 1907 stated that the female abdomen in *D. greeni* was 3-segmented. Van Douwe stated that the female abdomen was 2-segmented in *Paradiaptomus schultzei* and *P. similis*. Gurney, 1931, reported as the result of an examination of new material of *P. similis* that the female abdomen is 3-segmented: this would be presumptive evidence that these forms should be considered as *Diaptomi*. It seems probable, moreover, that *P. schultzei* and *P. similis* are not specifically distinct and should be considered as synonymous.

As pointed out by Gurney, 1929, it is sometimes difficult to separate these genera. The typical large, curved spine on the posterior surface of the exopodite of the male fifth foot in *Metadiaptomus* may be much smaller in some species and may be found more distad on the exopodite until it is sometimes difficult to decide whether it should be considered as located on the posterior surface or as terminal. That is, the terminal hook of *Lovenula* is doubtless homologous with the curved spine of *Metadiaptomus*. Probably it is also homologous with the "external" spine of *Paradiaptomus*.

LITERATURE CITED

- BRADY, G. S. 1913. *On freshwater Entomostraca from various parts of South Africa.* Ann. Natal Mus., vol. 2, pt. 4, pp. 459-584.
- BREHM, V. 1927. *Ordnung der Crustacea Entomostraca. Handbuch der Zoologie.* Kükenthal & Krumbach. 3rd Bd. 4 Lief. pp. 435-496.
- COOPER, ARNOLD W. 1906. *Notes on a new species of Gymnoplea from Richmond, Natal, South Africa; Adiaptomus natalensis (gen et sp. nov.).* Ann. Natal Govern. Mus. 1, p. 97-103, 1 pl.
- DADAY, E. VON. 1908. *Entomostraca et Hydrachnidae e Tibet.* Records of the Indian Mus., Calcutta, 2, 1908-1909: 323-341, 9 figs.
- 1908. *Adatok német-Kelet-Afrika Édesvíci mikrofaunájának ismeretéhez.* Math. Termés. Értesetö. 26-43-57.
- 1910. *Species aliquot novae Entomostracorum.* Arch. zool. Budapest, Vol. 1, p. 187-195, 3 tab.
- VAN DOUWE, CARL. 1912. *Copepoda. Neue Süßwasser-Copepoden aus Südafrika. Zoolog. und Anthropol. Ergebnisse einer Forschungsreise im westlichen u. zentralen Südafrika in den Jahre 1903-1905 von Dr. Leonard Schultze.* Bd. 5. Syst. & Tiergeog. Lief. 1, pp. 23-32, 1 pl.
- GIESBRECHT, W. UND O. SCHMEIL. 1899. *Copepoda. I. Gymnoplea. Das Tierreich* Lief. 6, XVI, 169 pp., 31 figs.
- GROCHMALICKI, J. 1913. *Beiträge zur Kenntnis der Süßwasserfauna Ostafrikas.* Anz. der Akad. Wiss. Krakau, Math-naturw. Kl. Reihe B. Nr. 7 B, 2 Taf., 1913, pp. 517-537.
- DE GUERNE & RICHARD. 1890. *Diagnose d'un Diaptomus nouveau du Congo. Description du Diaptomus alluaudi, n. sp. recueilli par M. Alluaud dans un réservoir d'eau douce à Lanzarote (Canaries),* in: Bull. Soc. zool. France, Vol. 15, p. 198-200.
- 1894. *Diaptomus chevreuxi, Copépode nouveau d'Algérie. Avec 5 fig.* Bull. Soc. zool. France, T. 19, p. 176-179, figs. 1-5.
- GURNEY, R. 1904. *On a small collection of freshwater Entomostraca from South Africa.* Proc. Zool. Soc. Lond. II, pp. 298-301.
- 1907. *On two new Entomostraca from Ceylon.* Spolia Zeylanica Vol. 4, pp. 126-134, 2 pls.
- 1929. *Notes on the Diaptomidae of South Africa.* Ann. & Mag. Nat. Hist. 4, pp. 572-584.
- 1931. *A species of fresh-water Copepod, Paradiaptomus greeni Gurney, common to South Africa, Ceylon, and India.* Zool. Anz. 92 (11/12) pp. 301-303, figs. 1-5.
- KIEFER, FRIEDRICH. 1928. *Beiträge zur Copepodenkunde.* Zool. Anz. Bd. 76, Heft 1/2, pp. 5-18.
- 1929. *Neue und wenig bekannte Süßwasser-Copepoden aus Südafrika.* Zool. Anz. 15 Marz 1929. Bd. 80, heft 10/12, pp. 309-310.
- LOVÉN, L. 1847. *Fyra nya arter af Sötvattens-Crustaceen från Södra Afrika.* Kongl. Vet. Akad. Handl. 1845, pp. 427-439, Taf. III-VI.
- LOWNDES, A. G. 1930. *Freshwater Copepoda from Abyssinia collected by Mr. J. Omer-Cooper.* Proc. Zool. Soc. Lond. Part I, 1930, pp. 161-179. 4 pls.
- METHUEN, PAUL A. 1910. *On a collection of freshwater Crustacea from the Transvaal.* Proc. Zool. Soc. London 1910 p. 148-166, 11 pls., 2 figs.
- RÜHE, F. E. 1921. *Die Süßwasser-Crustaceen der deutschen Südpolar-Expedition 1901-1903 mit Ausschluss der Ostracoden.* Deutsch. Südpol. Ex. 1901-1903. XVI Bd., Zool. VIII Bd. Pp. 5-66.

- SARS, G. O. 1895. *On some South African Entomostraca raised from dried mud.* Skrift. Vidensk. Selsk. Christiania, 1895, No. 8, p. 1; 1-56.
- 1899. *On the genus Broteas of Lovén, with description of the type species: Broteas falcifer Lov.* Arch. Math. og Naturvid. Kristiania, 21: pp. 1-27, pl. IV.
- 1907. *On two new species of the genus Diaptomus from South Africa.* Arch. Math. Nat. Kristiania Bd. 28, No. 8, 17 pp., 2 pls.
- 1927. *The fresh-water Entomostraca of the Cape Province (Union of South Africa).* Ann. South Afric. Mus. Vol. 25, p. 85-149, 12 pls.
- ULJANIN, W. N. 1875. *Crustacea of Turkestan.* Part I.

ZOOLOGY.—*Metagonimoides oregonensis*, a new trematode from a raccoon.¹ EMMETT W. PRICE, Bureau of Animal Industry, United States Department of Agriculture. (Communicated by ELOISE B. CRAM.)

Among some specimens recently referred to the writer by Dr. D. Sinitsin were a few specimens of a trematode which had been collected by Dr. J. N. Shaw, Oregon State College, Corvallis, Oregon, from the intestine of a raccoon. This fluke is closely related to species of the heterophyid genus *Metagonimus* Katsurada, but differs from them in certain characters which are regarded as sufficient to warrant the erection of a new genus. For this form the name *Metagonimoides oregonensis* n. g., n. sp., is proposed.

Metagonimoides new genus.

Generic diagnosis.—Heterophyidae: Body piriform in outline, strongly flattened dorso-ventrally. Oral sucker terminal; acetabulum well developed, lateral, directed antero-medially, and opening into a shallow genital sinus as in *Metagonimus*. Seminal vesicle slender and showing several constrictions. Testes oval, situated opposite each other at posterior end of body. Ovary irregular in shape, pretesticular, slightly to right of median line; seminal receptacle well developed; Laurer's canal present. Vitellaria lateral, extending from level of base of pharynx to posterior end of body. Uterus S-shaped, never extending caudad of ovary. Excretory vesicle Y-shaped, with short, wide stem and relatively short branches. Parasitic in intestinal tract of mammals.

Type species.—*Metagonimoides oregonensis* new species.

Metagonimoides oregonensis new species.

Figs. 1, 2.

Description.—*Metagonimoides*: Body piriform in outline, 589 to 688 μ long by 573 to 852 μ wide, strongly flattened dorso-ventrally. The cuticle is missing in all specimens available and it is not possible to determine whether spines are present or not. Oral sucker cup-shaped, 93 to 114 μ in diameter, terminal

¹ Received August 3, 1931.